11058EQ

Chronological Change in EEGs of a Child while Concentrating on Tasks

Kimiko KAWANO, Mikio YAMAMOTO, Hideyuki KOKUBO, Masataka TANAKA,
Weizhong CHEN, Tong ZHANG and Tomoko KOKADO

子供における課題集中時脳波の経年変化

河野貴美子、山本幹男、小久保秀之、田中昌孝、陳　偉中、張 トウ、古角智子

Reprinted from

Journal of International Society of Life Information Science (ISLIS)
J. Intl. Soc. Life Info. Sci. *Vol. 20, No. 1, March 2002*
The Thirteenth Symposium on Life Information Science
March 1-2, 2002, Tokyo Institute of Technology, Tokyo

ISLIS Head Office
c/o Yamamoto Bio-Emission Laboratory
National Institute of Radiological Sciences (NIRS)
9-1, Anagawa-4, Inage-ku, Chiba-shi 263-8555 JAPAN
Phone: +81-43-206-3066 Fax: +81-43-206-3069
http://wwwsoc.nii.ac.jp/islis/
E-mail: islis@nirs.go.jp

Journal of International Society of Life Information Science (ISLIS)
J. Intl. Soc. Life Info. Sci. Vol. 20, No.1, March 2002
The Thirteenth Symposium on Life Information Science
March 1-2, 2002, Tokyo Institute of Technology, Tokyo

Chronological Change in EEGs of a Child while Concentrating on Tasks

Kimiko KAWANO[1,2], Mikio YAMAMOTO[2], Hideyuki KOKUBO[2,3], Masataka TANAKA[2,3], Weizhong CHEN[2,3], Tong ZHANG[2,3], Tomoko KOKADO[2,3]

[1] *Centre for Informatics and Sciences, Nippon Medical School (Tokyo, Japan)*
[2] *National Institute of Radiological Sciences (Chiba, Japan)*
[3] *The Institute for Future Technology (Tokyo, Japan)*

Abstract: Physiological measurements during concentration on tasks have been carried out for three years with children who have been practicing a kind of image training and rapid reading. In this report, EEG changes of one subject, a 9-year-old boy in 2001, are reported. Measurements from three experiments were analyzed during tasks with the eyes closed. The tasks were resting, visual imaging and rapid reading using a blindfold (blind reading). Frequency of α waves became faster with age. The tendency for high frequency α waves during visual imaging and blind reading was clearer as the subject became older. The older the subject became, the larger the α amplitude on the occipital area became. But α suppression during rapid reading was observed at a lower age. During hypnosis-like induction of image and getting the contents of a book while blindfolded, the subject was considered to be in a so-called ASC (altered state of consciousness). In such a state, the ratio of the α amplitude on the frontal to the occipital area (Fp_2/O_2) becomes usually large. In this work, the ratio became really large during rapid reading. At that time, lag time of α waves on the frontal to the occipital area, as an indicator of concentration, became shorter than in the resting state. The subject seemed to be in the concentrating state. Fmθ which is considered to appear in deep concentration, was not observed so often for this subject. β waves tended to appear dominantly on the left hemisphere and only sometimes on the right or both occipital areas.

Keywords: EEG, α wave, α-frequency, frontal α-wave, child, concentration, ASC

1. Introduction

The authors have periodically measured EEGs of children who attended a kind of mental faculties development class and tried to study changes with their development progress. The results of one experiment were reported at the ISLIS 9th Symposium in 2000[1]. Since that experiment, two more have been carried out. As a few subjects moved and tasks were changed slightly between experiments, data for only one subject who participated in all experiments were analyzed in this report. Reference is also made to data of other children at the same school who were measured by the authors in 1996[2].

Kimiko Kawano; in[1] Centre Infor Sci., Nippon Medical School
1-1-5 Sendagi, Bunkyo-ku, Tokyo 113-8602.
Tel:81-3-3822-2131 ext.5392, Fax: 81-3-3823-2675,
E-mail: kim@nms.ac.jp

2. Subjects and Methods

EEGs of 12 monopolar signals were measured with ear lobes as reference, according to the international 10-20 method. The system and the method are basically the same as previously reported[1].

A power spectrum was obtained from 5.12 seconds (1024 points) EEG signals, excluding artifacts, such as EMG and EOG. Then, topograms of each band were given by the average of five spectra and the effective amplitude and peak frequency of the α band were obtained. Frequency bands used in this report were: 2-4

Hz for δ, 4-8 Hz for θ, 8-13 Hz for α and 13-30 Hz for β.

Lag time of the α waves between occipital and frontal areas was calculated by a cross-correlation method.

The subject of this report was a 9-year-old boy at the time of the third experiment, who attended a special ability training school. After control tasks in the resting state with the eyes closed and then open for 2 min each, the lesson was carried out by his teacher as usual. The contents of the lesson were selectively focused on imaging and rapid reading. In this report the tasks with the eyes closed were taken up for analysis; those tasks were resting, visual imagings and rapid reading using an eye mask. There were some more closed eye tasks, however in this report, only the common tasks through three experiments were used.

The θ and β waves were investigated throughout a whole session, including while the eyes were open.

3. Results and discussion

The authors have previously reported that the EEGs of children showed an apparent change with age and around the age of ten they became close to those of adults[2]. **Fig.1** shows the frequency changes of the α waves on the occipital area of the present subject. More

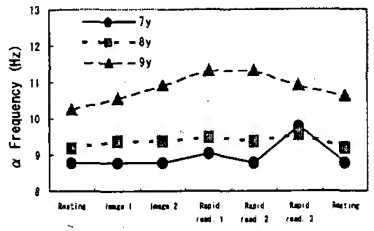

Fig.1 Frequency change of α waves on the occipital area

than the changes between each task, it was clearer that the older he was, the higher the frequency became. In this graph, 'Image 1' denotes an introductory relaxing image, 'Image 2' is various images, such as of space, a field of flowers or of bathing. 'Rapid read. 1, 2 and 3' differ in books and in methods for each experiment. 'Rapid read. 1 and 2' at 7 y. denote the beginning and ending parts while riffling through a book and 'Rapid read. 3' denotes data while reading a difficult, technical textbook. 'Rapid read. 1 and 2' at 8 y. are the same as those at 7 y.; and '3' is while trying to read with his hand on the book. 'Rapid read. 1' at 9 y. is also while riffling, but '2' is while the teacher was riffling the pages, and '3' is while laying his hand on the book. As the data during the period excluded artifacts of EMG or EOG were used and those situations on the subject for each year were not the same, it might be inappropriate to make a simple comparison in each value of different years inside one graph. However, using the average of five units, 5.12 seconds for each, was considered sufficient to standardize data during each task. In **Fig.1** the frequency became a little faster with brain activities.

During brain activities, the effective amplitude of the α waves on the occipital area generally becomes small. While leading the subject to relax in the first stage, the α waves became larger; on the other hand,

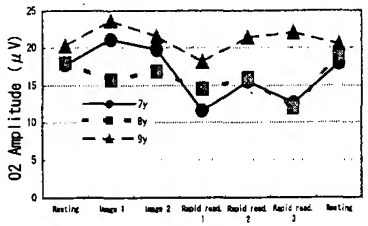

Fig.2 Effective amplitude of α waves on the occipital area

during rapid reading, they became smaller (**Fig.2**). At 9 y., however, the values during rapid reading were a little larger. Other subjects also showed the tendency of larger α waves during rapid reading. It was probably because of darkness with the eye mask.

Such a condition that the contents of books can be grasped even while blindfolded or only by putting a hand on the book is considered to be a so-called altered state of consciousness (ASC). In such a state, the α waves, which are usually large on the occipital area, appear also

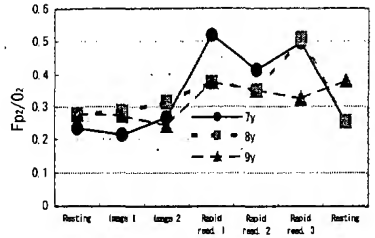

Fig.3 Ratio of the effective amplitude of α waves on the frontal to the occipital area (Fp2/O2)

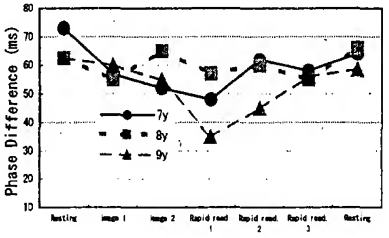

Fig.4 Lag time of α waves on the frontal to occipital area

on the frontal area[3].

So, the ratio of the effective amplitude of the α waves on the frontal to the occipital area (Fp2/O2) was calculated (**Fig.3**). The ratio became large during rapid reading, and that tendency seemed to be larger for a younger age. However, there was a possibility this reflected smaller occipital α waves at a younger age, as shown in **Fig.2**. Small α waves early in childhood were caused by the low α frequency; a lower part of the α spectrum fell into the θ band. The analysis of children's EEGs needs the consideration of both α and θ bands. It is a topic for future study.

The lag time between the frontal and occipital α waves becomes short when a subject concentrates on a task[3]. As shown in **Fig.4**, during rapid reading it became shorter than in the resting state. The authors' data obtained from an experiment on children attend a school to learn Soroban (Japanese abacus) showed that the older they were, the shorter the values were[4], though the tendency at 8 y. in **Fig.4** was a little different.

Fmθ which appears occasionally around the frontal midline site (Fz) during deep concentration appeared only a few times on this subject and it seemed to appear around Pz rather than Fz. The β waves indicated the active area appeared dominantly in the left hemisphere, because of the linguistic activity, and they appeared only sometimes on the right or both occipital visual areas.

The study is still in progress. Hereafter, as the children grow and learn more, how the physiological data change will be analyzed in addition to other data for all subjects.

Acknowledgments

The authors express their sincere thanks to Shichida Child Academy (Principal: M. Shichida, President: M. Toyama), the tutor, Yumiko Tobitani and all participants in this study. This study was partly supported by "Study on Human Potential in Physics and Physiology" (Representative: Mikio Yamamoto) and "A Study on Measurements of EEG as Life Information" (Representative: Kimiko Kawano).

References

1) Kawano, K., Yamamoto, M., Hirasawa, M., Kokubo, H., Kokado, T., Taniguchi, J. and Tanaka, M.: EEG Analysis of Children while Concentrating on Tasks -Part II-. *J. Intl. Soc. Life Info. Sci.* **18**(1): 121-126, 2000
2) Kawano, K., Yamamoto, M., Hirasawa, M., Kokubo, H. and Yasuda, N.: EEG Analysis of Children while Concentrating on Tasks. *J. Intl. Soc. Life Info. Sci.* **15**(1): 109-114, 1997
3) Kawano, K.: The Study on α Waves in the Frontal Region. *Extended Abstracts of the 44th Spring Meeting of the Jpn. Soc. of Appl. Phys. and Related Soc. No1:* 451, 1998 [in Japanese]
4) Kawano, K., Muramatsu, N. and Shinagawa, Y.: (EEG Measurements with the Progress of Japanese Abacus and the Correlation between the Age and EEG Fractal Dimension.) *Jpn. J. EEG EMG* **21**(2): 119, 1993 [in Japanese]

子供における課題集中時脳波の経年変化

(Chronological Change in EEGs of a Child while Concentrating on Tasks)

河野貴美子[1,2]、山本幹男[2]、小久保秀之[2,3]、田中昌孝[2,3]、
陳偉中[2,3]、張 トウ[2,3]、古角智子[2,3]
(Kimiko KAWANO[1,2], Mikio YAMAMOTO[2], Hideyuki KOKUBO[2,3],
Masataka TANAKA[2,3], Weizhong CHEN[2,3], Tong ZHANG[2,3], Tomoko KOKADO[2,3])

[1] 日本医科大学 情報科学センター(東京)
[2] 放射線医学総合研究所(千葉)
[3] 未来工学研究所(東京)

要旨：イメージ訓練や速読訓練を積んだ子供たちを対象に3年間にわたり、課題集中時の生理計測を行った。その内、3年間通して計測した被験者の一人(2001年計測時点で9歳の男児)について、閉眼課題(安静、イメージ、目隠し速読)実施中の脳波経年変化を検討した。α波の周波数は年齢と共に高くなり、イメージ課題や目隠しして本を速読する課題で速波化する傾向は年齢が高いほど明かであった。後頭部のα波は年齢が高い方が大きい傾向があり、速読中の平均振幅減少はむしろ低年齢で顕著に見られた。催眠誘導的なイメージ想起や閉眼のまま本の内容を読み取るような課題では、変性意識的な状況が考えられる。そのような状態では、後頭に対する前頭α波の平均振幅比(Fp_2/O_2)が安静時より大きくなるが、本実験でも速読中はこの比が大きくなった。そのとき、後頭に対する前頭α波の位相ずれ時間は短かめになり、集中度の増大が窺えた。集中時に前頭中央部(Fz)に出現するとされるFmθはこの被験者にも多少見られたが、顕著とはいえず、またFzよりPzに出現するような傾向があった。β波は、全般的には左半球優位であったが、ときに右後頭部優位あるいは左右後頭部に現れていた。

Keywords: EEG, α wave, α-frequency, frontal α-wave, child, concentration, ASC

1. はじめに

筆者らは、能力開発教室に通う子供たちの脳波を継続的に計測し、能力の開発に伴う変化を捉える試みを行っている。第1回目の実験結果は一昨年報告したが[1]、その後、毎年実験を重ね、全3回行った。ただし、被験者には一部入れ替わりがあり、課題も年ごとに多少異なる。そこで全3回とも計測を行ったうちの一人について、今回脳波の経年変化を検討した。筆者らは、1997年にも同教室における異年齢層の子供たちの脳波計測結果について報告しており[2]、その結果も考慮の上、報告する。

河野貴美子; 日本医科大学, 情報科学センター
〒113-8602 東京都文京区千駄木 1-1-5
Tel 03-3822-2131, 内 5392,
Fax. 03-3823-2675, E-mail: kim@nms.ac.j

2. 実験方法および被験者

脳波は両耳朶を基準電極とした国際10-20法に基づく12箇所からの単極導出で、装置、計測方法など基本的に前報告[1]と同様である。

解析は各課題ごとに、アーティファクトを避けた5.12秒間(1024ポイント)を1単位としたパワースペクトラムの5回平均により各帯域別トポグラフを描き、そのパターンを検討するとともに、α帯域 における平均振幅値とピーク周波数を求めた。用いた周波数帯域は、δ(2ー4Hz)、θ(4ー8Hz)、α(8ー13Hz)、β(13ー30Hz)である。

また、後頭ー前頭間α波の位相ずれ時間を、右後頭(O_2)と右前頭(Fp_2)脳波の相互相関の計算から求めた。

被験者は、能力開発教室に通う男児(第3回実験時点で9才6ヶ月)である。実験は安静の閉眼、開眼各2分計測の後、担当の先生にほぼ日常の授業通り進めてもらいつつ、課題としてはイメージや透視、速読を重点的に行った。その内、本報告では閉眼による課題、すなわち、最初の安静、目を閉じて気分を落ち着かせる導入、それに続くさまざまなイメージ、そして目隠しをして本をパラパラめくりながら内容を読み取る閉眼速読、最後に再び目を閉じての安静について解析した。他に閉眼での課題として色当てや紙に書いた文字の透視などを行った回もあるが、今回は3回に共通の上記課題のみ取り上げた。

その他の帯域は開眼課題も含め、全体を通してトポグラフにより検討した。

3. 結果および考察

子供の脳波は年齢と共に大きく変化し、10歳前後でほぼ大人の脳波に近付くことを以前報告した[2]。**Fig.1**に後頭部α帯域におけるピーク周波数変化を示したが、課題実施による周波数変化以上に年齢が高くなるにつれ、周波数が高くなっていることが明かである。グラフ中、'Image1' と表記したものは、導入時のリラックス誘導、'Image2' は宇宙、花畑、風呂など回ごとに異なるさまざまな想起イメージである。'速読の1、2、3'は本や方法を変えて行ったもので、実験ごとに多少異なる。すなわち、7歳時の'速読1、2'はパラパラ繰り返しめくりながら、物語の内容を考えているときの最初の部分と後半部分で、'3'は難しい専門書に取り組んでいる時のものである。8歳時も'1、2'は同様であるが、'3'は本の上に手を置いて内容を読み取ろうとしているときのもの、9歳時の'1'は、やはりパラパラとめくっているが、'2'は先生がめくっており、'3'は表紙に手を置いている。また、データ取得はアーティファクトのない箇所を優先したため、被験者の思考状態、先生の話し掛け状況等、各々に異なり、これらを年ごとの比較として単純に扱えるわけではない。しかし、5.12秒間のデータを5回加算平均し、ある程度長めの時間をとることで、その課題内での平均的な思考状況を捉えるよう試み、一つのグラフ上に表した。α波の周波数は、イメージが豊富に浮かんでいるとき高くなる傾向が**Fig.1**でも認められる。

そのような課題作業中は後頭部のα波平均振幅値は一般に小さくなる。**Fig.2**でも、導入でリラックスに導いたときはα波が多少大きくなり、速読課題では小さめになった。9歳時の'速読2、3''では多少大きくなっているが、他の被験者でも速読時は目隠しすることによりかえってα波が大きくなる例が、年度を問わず見られた。

速読時、目隠しや単に表紙に手を置いただけで内容が読み取れるような状態は、変性意識にも似た状態が考えられる。このような状態では、通常は後頭部に大きいα波が、前頭部にも現れてくる[3]。

そこで後頭に対する前頭α波の平均振幅比(Fp_2/O_2)を計算した(**Fig.3**)。速読時には比が大きくなる傾向が見られるが、年齢的に若いときの方がその傾向があるように見える。しかし、これは**Fig.2**にみられるように、後頭部のα波が年齢と共に大きくなることも反映していると思われる。年齢の低いときのα波が小さく計測されるのは、一つにはその周波数が低く、一部θ帯域にかかってしまうためである。子供の場合には両帯域にまたがる解析が必要であり、今後の課題である。

また、筆者が集中度の指標として使っている後頭に対する前頭α波の位相ずれ時間(**Fig.4**)は、速読中小さくなる、すなわち集中度が増す傾向がみられる。8歳時の傾向が多少違うが、以前、珠算塾に通う子供たちを計測した結果からは、年齢が高くなるにつれ集中度が上がることが見られている[4]。

集中時に前頭中央部に現れるFmθは、この被験者でも多少見られたが、頻度は少なく、FzよりPz寄りに現れ

るような様子が見られた。また、活動を示すβ波は、全般的には言語活動により左半球優位のことが多かったが、ときに右または左右後頭部に現れ、イメージ想起を窺わせた。

本実験はまだ継続中であり、今後、成長また学習に伴い、どのように変化していくか、同時に計測している他の被験者の経過と共に、さらに検討を重ねていくつもりである。

謝辞

本実験は、七田チャイルドアカデミー(校長:七田眞氏、社長:藤山守重氏)講師:飛谷ユミ子氏他の協力を得て行われました。被験者およびご協力者に深甚なる謝意を表明いたします。なお、本研究は一部、「潜在能力の物理 生理学による実証的研究」(課題代表者: 山本幹男)の内、「脳波による生命情報の計測に関する研究」(課題代表者: 河野貴美子)として行われました。

参考文献

1) 河野貴美子、山本幹男、平澤雅彦、小久保秀之、古角智子、谷口順子、田中昌孝: 子供における課題集中時の脳波解析-Part II-. *J. Intl. Soc. Life Info. Sci.* **18**(1): 121-126, 2000
2) 河野貴美子、山本幹男、平澤雅彦、小久保秀之、安田仲宏:子供における課題集中時の脳波解析. *J.Intl. Soc. Life Info. Sci.* **15**(1): 109-114, 1997
3) 河野貴美子:前頭部に現れるα波の一考察. *第45回応用物理学関係連合講演会予稿集* No1: 451, 1998
4) 河野貴美子、村松尚可、品川嘉也:珠算発達過程の脳波およびそのフラクタル次元と年齢の相関. *脳波と筋電図* 21(2), 119, 1993